Ch. 13 Notes: MIXTURES AND SOLUTIONS

NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics.*

I. Types of mixtures
(**mixture** – *a physical blend of substances*)

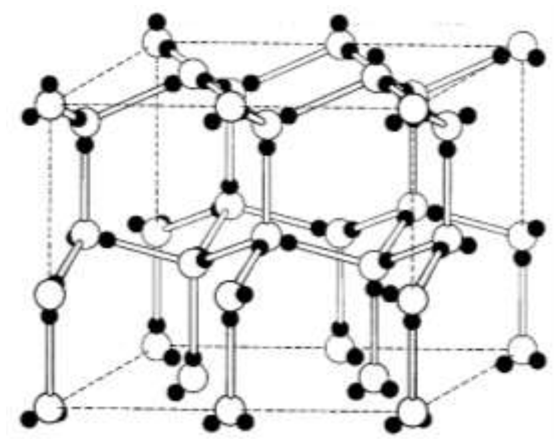
A. **heterogeneous mixture**– *physical mix with separate phases (parts)*
1) **suspension**
   a) *heterogeneous mixture that will settle if left alone*
   b) *largest particle sizes of all mixtures*
   c) can be easily filtered
2) *thixotropic mixture*
   a) heterogeneous mixture that settles into a bottom soil phase and top liquid phase
   b) *when stirred, it flows like liquid*
   c) *when left alone, it sits like a solid*
3) **colloid** (also called **colloidal suspension**)
   a) *heterogeneous mixtures with two phases of intermediate particle sizes*
   b) cannot be filtered or settled
   c) colloids show **Brownian motion** *(random movements)*
   d) electrostatic layers form
   e) examples: liquid and solid aerosol, emulsion, solid emulsion, sol, solid sol, paste, gel, foam, solid foam
   f) **Tyndall effect**—visible light transmitted by scattering through a colloid or suspension
      1) light will not show a path thorough a solution
      2) light will show a path through a colloid and a suspension
   g) **emulsions**
      i) *colloidal dispersions of liquid in liquid*
      ii) require an "emulsifier" like soap

B. **homogeneous mixture** (**solution**)—"soln"– *physical mix with one phase (part)* (more later in this chapter)
1) **aqueous solutions** *(aq)—water containing dissolved materials*
2) true solutions will not precipitate (form solids) or separate into layers
3) parts of a solution
   a) **solute**—*the substance being dissolved*
   a) **solvent**—*the substance doing the dissolving*
4) common solution (solute—solvent) combinations
   a) gas—gas
   b) gas—liquid
   c) liquid—liquid
   d) solid—liquid
   e) solid—solid
5) **soluble**—*dissolvable*
   insoluble = *not dissolvable*
6) **miscible**— *liquids that are soluble in each other*
   immiscible—*liquids that are not soluble in each other*
7) concentration
   a) **dilute**—more solvent than solute (weak)
   b) **concentrated**—more solute than solvent (strong)

PARTICLE SIZE:	*solution* <	*colloid (colloidal suspension)*	<	*suspension*
	salt water;	whipped cream;		dirt in water;
	acids; "air"	mayo; milk		wax in water

II. Water Molecule Characteristics

hydrogen bonding



ice crystal

A) colorless and odorless
B) neutral pH of 7
C) *triatomic* (three atoms)
D) *angular* shape with two unshared electron pairs
E) *polar (δ+ and δ- areas)*
F) **<u>hydrogen bonds</u>**—*an attraction between hydrogen and an unshared pair of an electronegative element on a neighboring molecule*
G) **<u>surface tension</u>**—*attraction between molecules on the surface of a liquid*
   1) surface tension makes water bead
   2) **surfactants**—*"wetting agents" which decrease surface tension* by breaking hydrogen bonds (soaps)
H) **<u>capillarity</u> (capillary action)—***moving upward, against gravity* (up through roots, etc.)
I) hexagonal crystals
J) *high specific heat*: 4.184 J/g°C (q = mcΔT… more later)
K) *high boiling point:* 100 °C

III. Solution Concentration

A) **<u>concentration</u> [ ]** – *amount of solute / amount of solvent*
B) **<u>molarity</u> (M)**
   1) *moles of solute / liters of soln.* **M = mol / L**
   2) M is read as "molar"
   3) examples

EXAMPLE 1) What is the molarity of a solution of 0.6784 mol NaCl in 4.5 L water?

$$M = \frac{\text{moles}}{\text{L}} \qquad \frac{0.6784 \text{ mol NaCl}}{4.5 \text{ L soln.}} = 0.15 \frac{\text{mol}}{\text{L}} = \boxed{0.15 \text{ M}}$$

EXAMPLE 2) A sugar solution contains 12.5 g of $C_{12}H_{22}O_{11}$ dissolved in 500.00 mL of water. What is the molarity of the solution?

$M = \frac{\text{moles}}{\text{L}}$ $\quad 12.5\ \cancel{g\ C_{12}H_{22}O_{11}} \times \frac{1\ \text{mol}\ C_{12}H_{22}O_{11}}{342.34\ \cancel{g\ C_{12}H_{22}O_{11}}} = 0.0365134077\ldots\ \text{mol}\ C_{12}H_{22}O_{11}$ (keep in calculator)

$500.00\ \cancel{mL} \times \frac{1\ L}{1000\ \cancel{mL}} = 0.50000\ L$ $\quad \frac{0.0365134077\ldots\ \text{mol}}{0.50000\ L} = \boxed{0.0730\ M}$

EXAMPLE 3) How many grams of KBr should be added to 977.6 mL of water to make a 3.0 M solution?

$977.6\ \cancel{mL} \times \frac{1\ L}{1000\ \cancel{mL}} = 0.9776\ L$

$3.0\ \frac{\cancel{mol\ KBr}}{\cancel{L}} \times 0.9776\ \cancel{L} \times \frac{119.00\ g\ KBr}{1\ \cancel{mol\ KBr}} = \boxed{350\ g\ KBr}$

C) (Chem 1H) – **<u>Molality (*m*)</u>** **(**script lower-case m)

1) molality (*m*) = $\frac{\text{moles of solute}}{\text{kg of solvent}}$
2) *m* is read as "molal"
3) examples

EXAMPLE 4) If a student adds 65.00 g of sucrose to 800.0 mL of water, what is the molality of the solution?

Mass of solute = 65.00 g $C_{12}H_{22}O_{11}$ Volume solvent = 800.0 mL H_2O *m* = ?

m = moles solute / kg solvent

$65.00\ \cancel{g\ C_{12}H_{22}O_{11}} \times \frac{1\ \text{mol}\ C_{12}H_{22}O_{11}}{342.30\ \cancel{g\ C_{12}H_{22}O_{11}}} = 0.1899\ \text{mol}\ C_{12}H_{22}O_{11}$

Knowing that 1 mL H_2O = 1 g H_2O…

Solvent: $800.0\ \cancel{g\ H_2O} \times \frac{1\ kg\ H_2O}{1000\ \cancel{g\ H_2O}} = 0.8000\ kg\ H_2O$

molality (*m*) = $\frac{\text{moles of solute}}{\text{kg of solvent}} = \frac{0.1899\ \text{mol}\ C_{12}H_{22}O_{11}}{0.8000\ kg\ H_2O} = \boxed{0.\ 2374\ m}$

EXAMPLE 5) How many grams of table salt should be added to 500. mL of water to make a 1.50 *m* solution?

Volume solvent = 500.0 mL H_2O *m* = 1.50 *m* Mass of solute = ? g NaCl

Knowing that 1 mL H_2O = 1 g H_2O…

Solvent: $500.\ \cancel{g\ H_2O} \times \frac{1\ kg\ H_2O}{1000\ \cancel{g\ H_2O}} = 0.500\ kg\ H_2O$ $\quad m = \frac{\text{moles solute}}{\text{kg solvent}} = \frac{1.50\ \text{mol NaCl}}{1\ kg\ H_2O}$

$$\frac{1.50\ \text{mol NaCl}}{1\ \text{kg } H_2O} \times 0.500\ \text{kg } H_2O \times \frac{58.44\ \text{g NaCl}}{1\ \text{mol NaCl}} = \boxed{43.8\ \text{g NaCl}}$$

OVERVIEW OF OTHER CALCULATIONS… (Chem 1H)

D) *percent by mass* $= \dfrac{\text{mass of solute}}{\text{mass of solution}} \times 100$

E) *percent by volume* $= \dfrac{\text{volume of solute}}{\text{volume of solution}} \times 100$

F) *dilution* $M_1V_1 = M_2V_2$ (M = molarity, V = volume)

G) solubility of gases: **Henry's Law** – *the pressure of a gas is directly proportional to the solubility at a given temperature ($P \alpha\ S$)*

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

H) *mole fraction (X)* $X_A = \dfrac{n_A}{(n_A + n_b)}$ $X_B = \dfrac{n_B}{(n_A + n_b)}$

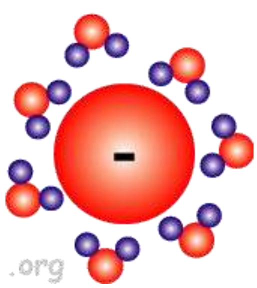
where n = number of moles

IV. **Solvation**—*the dissolving of a solute into a solvent*

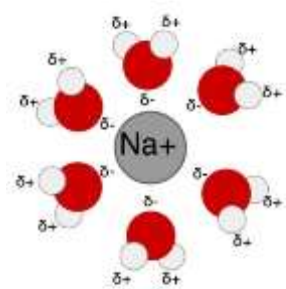
A) *hydration—a specific kind of solvation, when water is the solvent*

B) aqueous solutions of ionic cmpds.

1) water hydrating an anion: water's partially positive (δ+) end points inward, surrounding the anion
2) water hydrating an cation: water's partially negative (δ-) end points inward, surrounding the cation



water hydrating an anion



water hydrating a cation

(Sources: MCAT-review.org, humboldt.edu)

C) aqueous solutions of molecular cmpds.

1) polar molecular cmpds dissolve in water
2) nonpolar molecular cmpds don't dissolve in water

V. Solution Formation (abbreviation for solution = *soln.*)

A) *SOLUTE + SOLVENT = SOLUTION*

B) "**Like dissolves like**"

SOLUTE		**SOLVENT**	**SOLUTION?**
Polar/Ionic	+	**Polar/Ionic**	**Yes**
Polar/Ionic	+	**Nonpolar**	**No**
Nonpolar	+	**Polar/Ionic**	**No**
Nonpolar	+	**Nonpolar**	**Yes**

POLAR / IONIC EXAMPLES:

All BI**	**Salts****	**Water**
All TI**	**Sugars**	**Non-symmetrical molecules**
All OTHER ionic**	**Acids (vinegar, etc.)**	**"Hydrophilic" substances**
All crisscrossed formulas**	**Alcohols**	

** generalizing! (we do not deal with exceptions)

NONPOLAR EXAMPLES:

Oil	**Wax/Paraffin**	**Symmetrical molecules**
Diatomics ("Super 7")	**Noble gases**	**Fats**
Hydrocarbons: methane, propane, butane, octane…		**"Hydrophobic" substances**

C) *Factors which increase solvation (dissolving) rate:*

1) *surface area*—crush up solids (increase surface area [S.A.])
2) *agitation*—stirring, swirling, shaking
3) *temperature*—heating usually causes increased solvation

D. common examples of different types of solutions

solute-solvent:

1) gas-gas: atmospheric air
2) gas-liquid: carbonated water
3) liquid-liquid: alcohol in water
4) solid-liquid: sugar in water
5) solid-solid: metal alloys such as brass

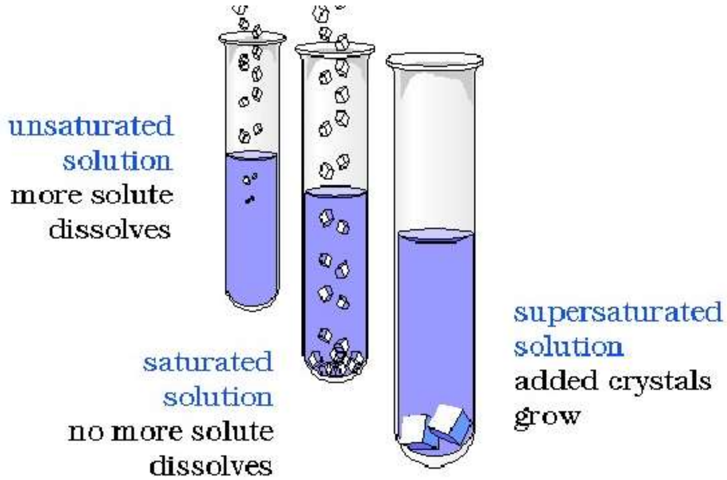
VI. **Solubility**

A) *the maximum amount of a solute* (substance being dissolved) *which will dissolve in a given amount of solvent* (substance doing the dissolving)

B) **miscible**—*the ability of liquids to mix* *(opposite =* **immiscible***)*

C) solution descriptions

1) **unsaturated**—small amount of solute; completely dissolved; room for more
2) **saturated**—too much solute; not all dissolved; excess settles on the bottom
3) **supersaturated**—an unstable solution formed from heating a saturated solution until all the solid dissolves; can recrystallize when cooled



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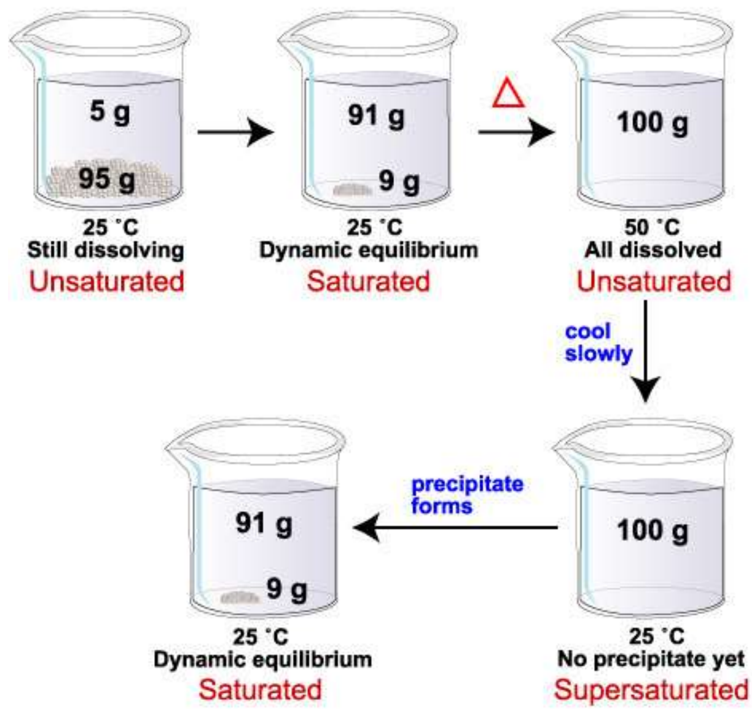

(Source: pixshark)

VII. Electrolytes and Nonelectrolytes

A) **electrolytes**—*conductors in aqueous solution* (usually ionic compounds and acids)

1) **weak electrolyte**—*a small fraction of the solute is as free ions*
2) **strong electrolyte**—*almost all of the solute is as free ions*

B) **nonelectrolytes**—*nonconductors in aqueous solution* (usually molecular and organic compounds)

VIII. Water of Hydration (review)

A) **water of hydration**—*water molecules chemically integrated into a crystalline structure*

B) *hydrate—a compound with water in its structure*

1) *general formula: [compound]·H_2O*

2) *naming: [compound name] (prefix)hydrate*

$CuSO_4 \cdot 5H_2O$ copper(II) sulfate pentahydrate

C) *anhydrous—a hydrate without its water of hydration*

$Na_2SO_4 \cdot 2H_2O \rightarrow Na_2SO_4 + 2H_2O$

sodium sulfate dihydrate anhydrous sodium sulfate + water

D) **efflorescence**—the release of water by a hydrate (heating not needed)

E) **hygroscopic**—remove water from the atmosphere

F) **deliquescence**—absorbing excess water from the atmosphere to form a liquid substance

G) **desiccant**

1) a *drying agent* which is hygroscopic

2) examples: Damp Rid; packets of silica powder in shoe boxes

IX. **Colligative Properties** of Solutions (details, Chem 1H)

A) *these properties relate to the number of solute particles*

B) examples

1) **vapor pressure lowering** (volatile solute α v.p.)

2) **boiling point elevation**

a) BPE α solute concentration

b) $\Delta T_b = K_b m$ BPE = (molal b.p. elevation constant) x (molality)

3) **freezing point depression**

a) FPD α solute concentration

b) $\Delta T_f = K_f m$ BPE = (molal f.p. depression constant) x (molality)

C) osmosis

1) **osmosis**—*diffusion of a solvent through a semipermeable membrane, from dilute to concentrated*

2) **osmotic pressure**—*amount of additional pressure from the water molecules that moved into the concentrated solution*